Polykron: Using FPGAs to Build Adaptive Measurement Hardware

Abstract

Alan Mink and colleagues at NIST ITL have developed the Multikron, a hardware chip that enables highly accurate measurement of software systems with reduction in the perturbation normally associated with software probes. The Multikron chip has been used to measure software implementations of communication protocols, operating systems, and web servers, and has been included by Intel in some of its computer chips. Because it has been designed as a computer chip, the Multikron can be fabricated at the economies of scale generally associated with integrated circuit (IC) technology; however, the use of IC technology also introduces some limitations. Specifically, the Multikron provides a fixed set of counters and timestamps. In applications where more complicated measurements are required, the Multikron chip might not suffice. In addition, the Multikron counters have a fixed precision and the timestamps have a fixed resolution. We have already seen that for most network measurement applications the resolution of the Multikron is excessive. By using Field-Programmable Gate Arrays (FPGAs), an increasingly promising re-configurable chip technology, we can extend the basic ideas behind the Multikron to build adaptive measurement hardware.

Over the past decade, FPGA technology has decreased in cost, increased in the number of gates per chip, and has increased in effective speed (though it still falls short of the speed achievable with hard-wired ICs). Industry expects to make further improvement in these characteristics during the next five to ten years. For further information on currently available FPGA technology, consult Virtual Computer Corporation (http://www.vcc.com/), Xilinx (http://www.xilinx.com/products/products.htm), and Altera (http://www.altera.com/html/literature/literature.html). FPGA technology appears to be so promising that DARPA has established Adaptive Computing Systems (ACS), a $20M a year program to build software tools to support the development of FPGA designs and to facilitate rapid reconfiguration. Our idea is that FPGA technology can be used to design and implement a reconfigurable hardware measurement system, which we call the Polykron. We propose to implement the current functionality of the Multikron using FPGAs, and then to demonstrate that our Multikron can be reconfigured for specific measurement requirements. In addition, we propose to compare the performance of the Multikron with the Polykron. This seed work could lead to a competency proposal relating to adaptive hardware measurement systems.

Proposed Tasks and Deliverables

Task 1   Acquire an FPGA development system

Task 2   Create an FPGA design for the Multikron functionality

Task 3   Implement and test Polykron, the FPGA Multikron, using an existing application

Task 4   Reconfigure the Polykron to provide alternate measurement capabilities and test the new configuration

Task 5   Compare the performance of the Multikron and Polykron for the same application

Deliverables: 1. Polykron
2. Two measurement configurations for the Polykron (one of which is the Multikron)
3. Two papers: one describing the Polykron and one comparing the performance of the Polykron and Multikron